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Getting FIES ready for TESS

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An up-to 200-night radial velocity follow-up effort is being prepared for FIES, the high-resolution Fiber-fed Echelle Spectrograph at the 2.56-meter Nordic Optical Telescope (NOT). With support from NASA and MIT, the program aims to provide confirmation and mass measurements for exoplanet candidates discovered by TESS around bright, nearby stars. The observations are expected to start in mid-2019, and we are currently upgrading FIES to ensure the best possible level of precision and stability.

The Transiting Exoplanet Survey Satellite (TESS) was sucessfully launched from Cape Canaveral on 18 April 2018. On its 2-year mission, it will search almost the entire sky for transiting exoplanets around 500,000 nearby, bright stars.

TESS will observe for 27 days in each of its 26 observing sectors of 24° × 96°. The sectors are laid out so that they overlap in the JWST continous viewing zones, providing better sensitivity to longer period planets and potential atmosphere targets.

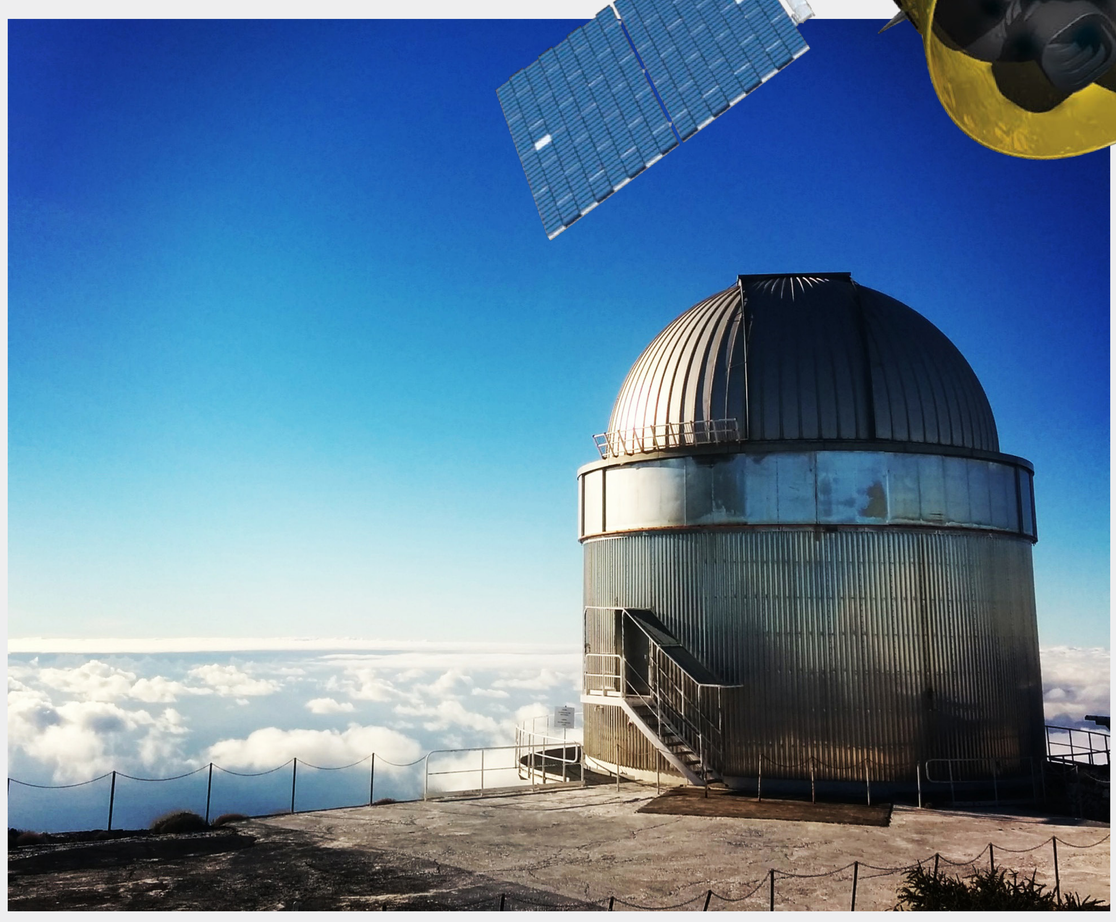

Figure 1: The 2.56-meter Nordic Optical Telescope (NOT) situated 2,382 m above the ocean at Observatorio Roque de Los Muchachos, La Palma.
Overlay: TESS, the Transiting Exoplanets Survey Satellite (Credit: NASA).

It is a Level 1 Requirement of the TESS mission to measure the mass of 50 small exoplanets. To ensure this is fulfilled, NASA and MIT will purchase telescope time at the NOT for an extensive follow-up program lead by DTU Space. With support from the Carlsberg Foundation, we are now upgrading FIES to deliver the required RV precision.

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New fiber feed

In 2017, new 89 µm octagonal fibers were installed to feed the light from the telescope to the spectrograph (see Figure 2). Octagonal fibers are known to scramble the light much better than circular fibers, meaning that variations in the fiber illumination due to seeing or guiding errors will not propagate into the spectrograph.

The octagonal high-res fiber is coupled into a 45×180 µm rectangular fiber before it enters the spectrograph. A combined image slicer and double scrambler is being manufactured to improve throughput and scrambling gain.

FIES users from the community have already reported a significant improvement in the RV precision of their measurements, and we have shown with standard star observations that the scrambling is stable within a few m s^{-1} (see Figure 3).

Fabry-Perot calibration source

In the fall of 2018, we will be integrating a pressure-stabilized Fabry-Perot étalon (FP) for improved wavelength calibration. The FP generates a spectrum of evenly spaced

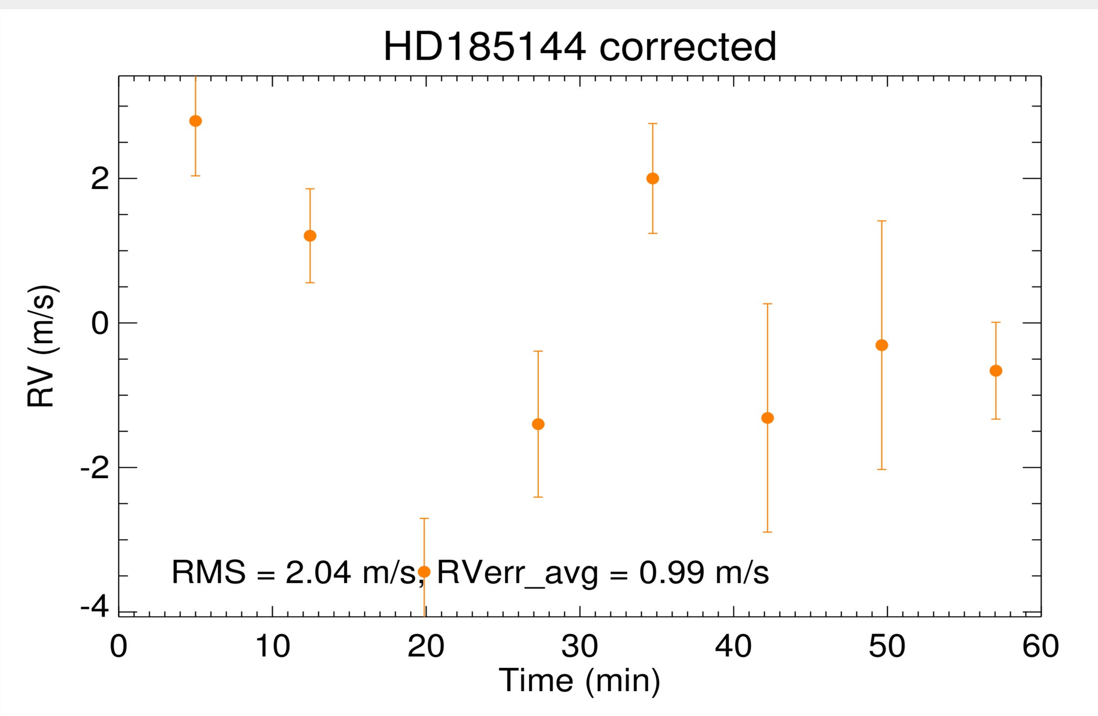

Figure 3: With fiber guiding disabled, an RV standard star was observed with varying fiber illumination (star intentionally offset from the center of the fiber). Thanks to the scrambling effect, the fiber output illumination remains stable, instead of inducing RV shifts. With the previous, circular fiber, a similar test would show apparent RV variations of tens or hundreds of ms^{-1}. This plot has been corrected for instrument drift using ThAr exposures between the observations.

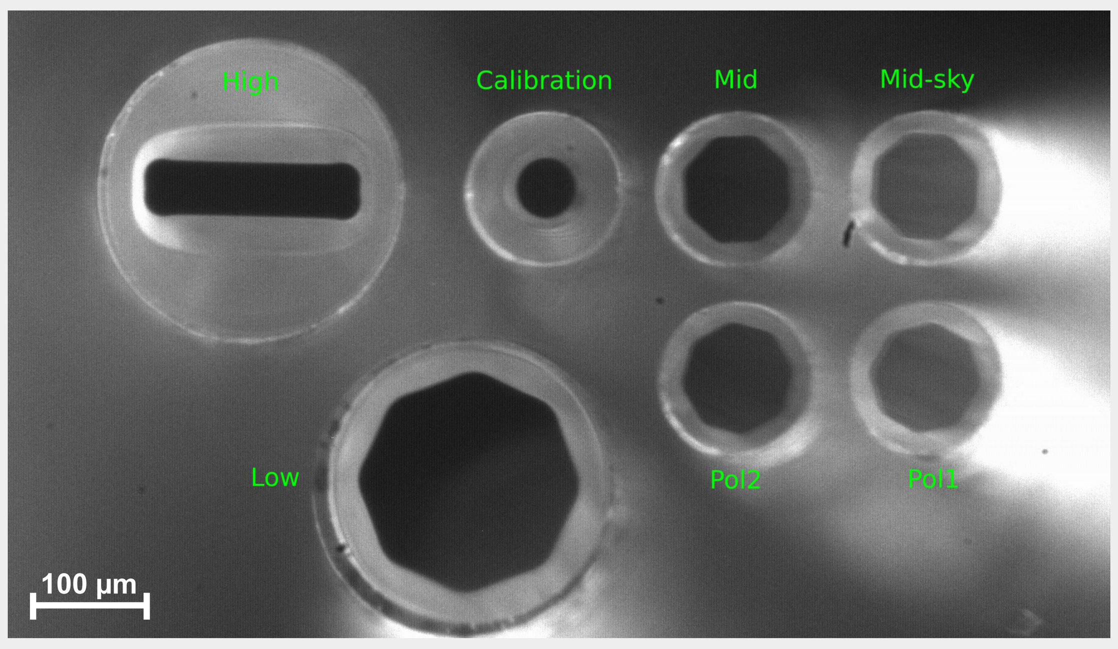

Figure 2: New slit plate, where the fibers from the telescope and the calibration unit end. Light is coupled into the rectangular high-res fiber from an octagonal fiber similar to the mid-res fibers.

peaks over the entire spectral range of the spectrograph – the ideal case for wavelength calibration.

The FP is expected to have a slow drift in wavelength, but it will be continously monitored with a laser interferometer that measures the drift precisely, such that it can be corrected for.

Pressure stabilization and monitoring

New, high-resolution sensors have been installed to monitor the atmospheric pressure and temperature inside the spectrograph.

We are in the process of designing a vacuum enclosure around the grating in order to alleviate the diurnal variation of the atmospheric pressure.

Improved pipeline and exposuremeter

We are adding significant improvements, including the implementation of FP calibration and the use of an already-installed exposuremeter inside the spectrograph. By monitoring the flux every few seconds during an exposure, we can integrate for the barycentric correction rather than rely on a single point. This becomes increasingly important with longer exposure times that will be used to observe some TESS candidates.